Advanced Materials for Rechargeable Lithium-Sulfur Batteries

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Rechargeable batteries are essential power supplies for our daily life, and they are widely used in portable electronics, hybrid electric vehicles, and grid energy storage. Lithium-ion (Li-ion) batteries, which have the highest energy density among rechargeable batteries, have reached the capacity limits of current electrode materials, such as transition metal oxides (*e.g.*, $LiCoO_2$, $LiMn_2O_4$, and $LiFePO_4$). To meet the increasing demand of high energy density batteries, rechargeable lithium-sulfur (Li-S) batteries are considered as one of the most promising systems with significant potential for many practical applications. Sulfur has a theoretical capacity of 1,672 mAh/g by taking two electrons per atom, which is an order of magnitude higher than those of transition metal oxides. However, several challenges impede practical application of Li-S batteries, such as high resistivity of sulfur, dissolution of intermediate polysulfides, and shuttle of these polysulfides from cathode to anode in Li-S batteries. Significant improvements have been achieved over the past years, but further improvements and better understanding of Li-S batteries are still needed.

This poster will present several strategies that have been developed including sulfur-conductive polymer nanocomposites, lithium/dissolved polysulfide cells, sandwiched Li_2S electrodes, and *in situ* formed Li_2S cathodes. A nanolayer of conductive polypyrrole was fabricated on sulfur particles, which can enhance electrical conductivity and reduce dissolution of polysulfides. Binder-free carbon nanotube current collector was used in lithium/dissolved polysulfide cells, which exhibit unprecedented capaciteis of 1,600 mAh/g in the first cycle and over 1,400 mAh/g after 50 cycles. Lithium metal anode is used in current Li-S batteries since the sulfur cathodes do not have any lithium in the initial stage, which is a safety hazard. Lithium-rich sulfur cathode materials such as Li_2S can allow a variety of non-lithium metal anodes to be used, which can advance the Li-S battery technology to an unprecedented level. However, the high reactivity of Li_2S results in limited approaches that have been explored. A sandwiched Li_2S electrode consisting of two layers of carbon nanotube paper has been developed which shows high capacities and high rate capabilities. In addition, a novel *in situ* formed Li_2S cathode is developed, which utilizes lithiated graphite as a lithium donor to convert lithium polysulfide Li_2S_6 to the end discharge product Li_2S. These materials and strategies are promising for practical applications.